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Value-added Information in Term Structure: The case of Malaysian Government Securities

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ABSTRACT

This study empirically examines the impact of value-added information in the risk premium on the predictability of longer maturity term structure about future short-term rates in Malaysian fixed income securities market. Regardless of the absence of a time-varying risk premium in the interest rate, the Generalized Method of Moment (GMM) results suggest that there is statistical evidence to support that the longer-term spread between long-term and short-term rates does have some significant power in predicting the changes in expected future short-term rate. This implies the stability of the short-term interest rates in Malaysia.

Keywords: Risk premium, term structure, Expectation Hypothesis, short-term interest rate, long-term interest rate, GMM, and Hansen's instrument validity test.

INTRODUCTION

The Malaysian emerging financial market, particularly fixed-Income Securities market has developed significantly in terms of its market size and the range of instruments and products. The market has also gained a higher level of market efficiency over the years. The development of the market has enhanced its role in supporting the growth and the competitiveness of the economy. As industrial activities are picking up, massive capital input is required. These massive activities

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require demand for a concomitant widening and deepening of the capital market as an efficient and reliable source of funding for private and public sector activities. To date, the fixed-income market has flourished into a vital component of financial landscape in this region. The banking system and the equities market play a critical role in fuelling growth during the era of rapid globalization. Given the importance of the fixed-income market, it is crucial to examine the information in the longer maturity term structure about future short-term rates in Malaysia to determine whether term spreads predict nominal interest rates with time-varying risk premium.

It is widely known that testing the information in the longer maturity term structure about future short-term rates in the presence of risk premia in emerging financial market such as the ASEAN economies are important for a number of reasons. First, it is related to the notion of informational efficiency of the bond and money markets: are there profitable arbitrage possibilities in these markets? Secondly, it is important in describing the transmission mechanism of monetary policy. The monetary authorities control the short-term rate, and only if there is a stable relation between short and long rates will the authorities also be able to control long rates and thereby influence real economic activity. Thirdly, it may contain useful information about future interest rates, inflation, and real economic activity. For example, the monetary authorities and policy makers may be able to use the term structure spread as an indicator of the inflationary pressures in the economy. Finally, it can also be used to infer agents expectations following a change in monetary policy (see, for example, Mankiw et al., (1986), and to evaluate the credibility of economic policy as in Andersen and Risager, (1988) Camarero and Tamarit (2002) and Compbell and Shiller (1991).

Many researchers have empirically tested the information content in the term structure of interest rate to predict changes in interest rates. However, the joint hypothesis of rational expectations and pure expectations theory of term structure has been rejected in most studies. Yet, some studies, including Fama (1984), Mishkin (1988), Hardouvelis (1994) and Campbell and Shiller (1991) provide empirical evidence that the term structure has predictive power regarding future short-term interest rates though less than required by the theory. Surprisingly, the United States, the country with the most sophisticated and liquid financial markets, provides the weakest and most inconsistent evidence for the expectations theory. Mankiw and Miron (1987) and many researchers following their lead propose that the lack of evidence for the United States could arise because monetary policy smoothens interest rates. Rudebusch (1995) explicitly model the interest rate targeting behavior of the Fed and show that this policy can result in the empirical failure of the expectations theory. Kugler (2000), Hardouvelis (1994), shows that the expectation hypothesis works better in European countries than in the US. They suggest that the hypothesis works best for the cases where monetary policy is restricted by an intermediate exchange rate target as in the European Exchange Rate Mechanism. The systematic policy response makes more predictable and leads to a good performance of the expectation theory.

THEORETICAL UNDERPINNINGS

This study examines the information in the longer maturity term structure about future short-term rates in emerging fixed-income securities market based on the testable version of Expectations Hypothesis (ET). This hypothesis posits that the continuously compounded yield to maturity of a p-period bond (for p = 1, 2… denoted by $R_{p,t}$ is determined solely by expectations of current and future yield on a set of q-period bonds $R_{q,t}$ where $p > q$. For zero coupon bonds, the fundamental term structure relationship, which states that the yield on a p-period bonds should equals the return on an q-period bond rolled over k times, where $k = p/q$. It can be summarized as a long-term interest rate being a geometric average of expected future short-term interest rates as shown in the following equation:

$$\left(1+R_{k,t}\right)=\left(1+E_t R_{1,t}\right)\times\left(1+E_t R_{1,t+1}\right)\times\ldots\times\left(1+E_t R_{t+k-1}\right)\times\zeta_k \tag{1}$$

where the term, $R_{k,t}$ denotes interest rates with a maturity of k at time t, and therefore, interest rates with a maturity of 1 month at time t are here expressed as $R_{1,t}$. Furthermore, the expected value of (·) at time t is indicated by E_t (.), and ζ_k is a term premium. For the pure expectations hypothesis to hold, the term premium needs to equal zero for all k. By transforming Equation (1) into the logarithm form, defining ? ? $r_{k,t}$ = ln (1+? $R_{k,t}$) and ζ_k = ln ζ_k, we have

$$r_{k,t}=\frac{1}{k}\left(E_1 r_{1,t+1}+\ldots+E_t r_{1,t+k-1}\right)+\zeta_k \tag{2}$$

Equation (2) implies that an increase (decrease) in the yield spread, which can be observed in the yield curve by plotting yields of financial assets as a function of maturities, is explained by investors' expectations of short-term rates rising (falling) in the future. There are four types of yield curve. A normal yield curve is a positively-sloped, which indicates that longer maturity bonds have a higher yield compared to shorter-term bonds due to the risks associated with time. A negatively-sloped curve, or inverted yield curve, on the other hand, shows that the shorter-term yields are higher than the longer-term yields, which can be a sign of upcoming recession. A flat yield curve is one in which the shorter- and longer-term yields are very close to each other, which is also a predictor of an economic transition. A humped yield curve is explained by investors' expectations of short-term rates increasing and long-term rates falling. The steepness of the slope of the yield curve is also seen as important indicator: the greater the slope, the greater the gap between short- and long-term rates. Following Campbell and Shiller (1991), by subtracting from Equation (2) and rearranging, we get

$$\frac{1}{k}\sum_{i=0}^{k-1}\left(E_t r_{1,t+i} - r_{1,t}\right) = r_{k,t} - r_{1,t} - \zeta_t \tag{3}$$

$$r_{k,t} - r_{1,t} = \frac{1}{k} = \sum_{i=0}^{k-1}\left(E_t \Delta r_{1,t+i}\right) + \zeta_t \tag{4}$$

Equation (4) becomes a basic equation for expectations theory in empirical studies. When the term premium is zero, this equation states that there is a linear relationship between the term spread between the k-month bond and the 1-month bond and the average expected change in the 1-month rate over the k periods. Thus, if short-term rates are expected to rise (decline), the term structure will be upward (downward) sloping.

Empirical results from previous works are mixed, but there has been an increase in evidences that support the expectation hypothesis recently. Results of the theory using data of various yields provide evidence in favor of expectation hypothesis (see, for Example, Camarero and Tamarit 2002; Esteve 2006; and Gerlach 2003). One problem with testing the ET is that equation (4) contains expectations of future short- term rates and therefore cannot be estimated directly. To solve this problem, let, $r_{1,i+j} \equiv E_t r_{1,t+i} + \zeta_{1,t+i}$ which states that the actual 1-month rate is equal to its expected value plus an expectation error. If we are willing to make the standard assumption that the expectation errors are serially uncorrelated, we can use this result to rewrite and rearranging equation (4) as

$$\frac{1}{N}\sum_{i=0}^{N-1}\left(r_{1,t+i} - r_{1,t}\right) = -\theta_N + r_{n,t} - r_{1,t} + \frac{1}{N}\sum_{i=0}^{N-1}\zeta_{1,t+i} \tag{5}$$

$$\frac{1}{N}\sum_{i=0}^{N-1}\left(r_{1,t+i} - r_{1,t}\right) = \alpha_n + \beta_N\left(r_{n,t} - r_{1,t}\right) + \eta_{n,t} \tag{6}$$

where: $r_{1,t+i} - r_{1,t}$ is changes in 3-month treasury bill rate. $r_{n,t} - r_{1,t}$, is term spreads; the difference between the 5-year Treasury bond rate and the 3-month Treasury bill rate at time t, and Greek letters represent the parameters.

The ET then holds that $\alpha_N = -\theta_N$ and $\beta_N = 1$. Therefore equation 6 became an estimated equation in empirical testing for ET taking into accounts that the error term, $\eta_{n,t} = \frac{1}{N}\sum_{i=0}^{N-1}\zeta_{1,t+i}$ obeys a moving average structure of order $N-1$. Equation

6 assumes that risk premium is time invariant. However the risk premium may differ across time. Mankiw and Miron (1986) argued that allowing for time-variation in the risk premium may be critical for understanding the movements of the term structure of interest rate in many countries. Since, the objective of this paper is to measure the time-varying risk premium in emerging fixed-income securities market; Equation 6 should be modified to incorporate the measurement of time-varying risk premium. To see this more clearly, we simplify equation 6 as

$$E_t\Delta r_{n,t} = -\theta_{n,t} + TS_{n,t}$$

where: $E_t\Delta r_{n,t} \equiv \frac{1}{N}\sum_{i=0}^{N-1}\left(E_t r_{1,t+i} - r_{1,t}\right)$ and $TS_{n,t} = r_{n,t} - r_{n,t}$.

Mankiw and Miron show that in the process of a time-varying term premium, the estimated value of β_N in equation 6 is given by:

$$\beta_N = \frac{\operatorname{var}\left(E\Delta r_N\right) + \operatorname{cov}\left(E\Delta r_N, \theta_N\right)}{\operatorname{var}\left(E\Delta r_N + \operatorname{var}\left(\theta_N\right) + 2\operatorname{cov}\left(E\Delta r_N, \theta_N\right)\right.} \quad (7)$$

Equation 7 indicates that if the variance of the risk premium is zero, the slope parameter is indeed unity. However, if there is a risk premium, the slope parameter can be negative or larger than unity and β_N will range between zero and unity if the covariance is not too large. In order to incorporate the risk premium into the model, we first estimate the volatility of short-term rate using GARCH (i,j) models[1]. More precisely, we estimate

$$\Delta r_t^{(3)} = \gamma_0 + \gamma_1 r_t^{(3)} + \varepsilon_t \quad (8)$$

where $\varepsilon_t \sim N\left(0, \sigma_t^2\right)$ and where

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1\alpha_{t-1}^2 \quad (9)$$

and then use (the logarithm of) the square of the estimated variance in the GARCH model that fit our data well as a measure of the risk premium, the strategy suggested by Pagan Ullah (1988) and applied by Gerlach (2003). Thus equation 6 can be modified to equation 10 to account for time-varying risk premium:

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[1] The GARCH specifications were chosen based on q statistic and LM test. For the details results contact the author.

(10)

where δ_N captures the impact of the risk premium.

DATA AND EMPIRICAL RESULTS

Description and Time-series Properties of the Data

Monthly data series are used to examine the term structure of 3-moth Treasury bill rate and 5-years government bond in Malaysia using monthly data during 1992:02-2004:09. 5-years government bond and Treasury bill yields are used in this study as a proxy measurement for long- and short-term interest rate respectively.

Table1 reports some summary statistics of each series. Asymmetrical distribution has a skewness value of zero, a right-skewed distribution has a positive value, and a left skewed distribution has a negative value. Kurtosis values provide some comparison of the series distribution to the normal distribution. The normal distribution is characterized by a typical bell- shape and holds a kurtosis value of three. Kurtosis values of higher than three are characteristic of distributions with fat tails and kurtosis values of less than three indicate light tails. Approximate near symmetry for each series can be inferred from Table 1. The skewness values are close to zero indicating near symmetry. The null hypothesis of kurtosis coefficients conforming to the normal distribution value of three is strongly rejected. The monthly short- and long-term interest rates on Malaysian government income securities are thus, not normally distributed- a conclusion which is confirmed by Jargue-Bera test. Kurtosis values less than three indicate excess kurtosis. Campbell *et al*. (1997) note that it is common when assuming continuously compounded returns to find excess kurtosis in historical returns.

Table1 Statistical indicators of nominal interest rates at different term to maturity

	TB3	**B5**
Mean	4.613469	5.541122
Median	3.950000	5.522000
Maximum	9.982000	8.950000
Minimum	2.341000	2.995000
Std. Dev.	1.950176	1.546714
Skewness	0.411589	-0.001161
Kurtosis	1.793396	1.943394
Jarque-Bera	13.06779	6.838077
P-value	(0.001)	(0.032)

Unit Root Tests

The time series properties of our data have been performed using unit root test such as ADF, PP and KPSS tests on interest rates and the term spreads. Table 2 report the unit root tests in individual interest rates and in spreads between long-term bond yield and short-term bond yield using ADF and PP tests. The Augmented Dickey-Fuller and Philip Perron tests clearly indicate that interest rates are non-stationary, I (1). The results also show that the spreads between 5-years bond yield and three month Treasury bill is stationary, I(0). This is in accordance with the Expectation Hypothesis of the Term Structure (ETTS).

However, it is widely acknowledged that the standard ADF and PP tests are not very informative on how to distinguish between a unit root and near unit root case and they are known to be of low power in small sample size. The ADF test, in particular experiences the loss of power when the autoregressive parameter is close to unity. The PP test, on the other hand, has poor size properties, i.e. it is biased towards the rejection of the null hypothesis when the series follows a MA process. Therefore, the alternative KPSS test proposed by Kwaitkoski et al. (1992) can be used not only as a complementary way to confirm the results of both ADF and PP but also to allow for the errors to be heteroscedastic and to obey an MA (N—1) structure since standard errors are computed using the approach suggested by Newey and West (1987). KPSS procedure assumes the univariate series can be decomposed into the sum of a deterministic trend, random walk and stationary I (0) disturbance $\sigma_t^{\wedge 2}$ and is based on a Lagrange Multiplier score testing principle. This test reverses the null and the alternative hypothesis. As reported in Table 3, the null hypothesis is accepted in favour of no unit root for most of the cases. These KPSS findings have further confirmed that all series are stationary after first difference.

Time Varying Risk Premium

The GARCH model used for this empirical analysis is to estimate the monthly innovation in the short-term interest rates and hence derived the implied series of $\sigma_t^{\wedge 2}$ as a measure of the risk premium. Table 4 report the estimated coefficients, Newey-West standard errors and the p-values, the value of Hansen's test and Walt test in both sections. The GARCH coefficients β_1 is statistically significant and the sum of the coefficients is less than one. This indicates the absence of the integrated GARCH. We consider the estimated values for as an approximate measure of the risk premium.

Testing the Expectation Hypothesis

The term structure of interest rate and the future path of interest rate estimations were carried using time series Generalized Method of Moments (GMM) technique.

Table2 ADF and PP Unit Root Tests with Intercept and a linear trend in Malaysian Data

Variables	**Level**				**First difference**			
	ADF		**PP**		**ADF**		**PP**	
	μ	τ	μ	τ	μ	τ	μ	τ
TB3	-1.968	-2.629	-1.541	-1.051	-7.897*	-7.866*	-11.354*	-11.383*
B5	-1.081	-1.872	-1.109	-1.902	-11.372*	-11.349*	-9.612*	-9.343*
TS(2)	-2.960**	-3.211**	-2.77**	-3.187**				
INT_RATE(1)	-8.492*	-8.473*	-8.802*	-8.777*				
INF_RATE	-10.799*	-11.523*	-10.873*	-11.529*				
RGDPG	-3.383**	-3.689**	-8.585*	-9.580*				

Notes: (*) and (**) denotes significant levels at 1% and 5% respectively (Mackinnon, 1996). The null hypothesis of unit root tests is that the series contains unit root (non-stationary) against the alternative hypothesis of no unit root (stationary). μ is the model with constants, and τ is the model with constants and linear trend.

Table 3 KPSS Unit Root Tests with Intercept and a Linear Trend in the Malaysian Data

Variables	Level		First difference	
	μ	τ	μ	τ
TB3	0.779*	0.173**	0.080	0.078
B5	0.831*	0.223*	0.101	0.090
TS	0.157	0.098		
INT_RATE	0.058	0.055		
INF_RATE	0.560	0.136		
RGDPG	0.240	0.154		

Note: (*) and (**) denotes significant level at 1% and 5% level respectively. The critical values are obtained from Kwaittakowski et al. (1992). The null hypothesis of KPSS unit root tests is that the series contain no unit root (stationary) against the alternative hypothesis of a unit root (non-stationary). μ is the model with constants, and τ is the model with constants and linear trend. TS, INT_RATE, INF_RATE AND RGDPG are stationary at the level and therefore, first difference stationary test is not conducted.

Table 4 Estimate of a GARCH (0, 1) model using Malaysian short-term interest rate

	α_0	α_1	β_1	$\alpha_1 + \beta_1$
1992:02-2004:09	0.024	-	0.899*	0.899
GARCH (0, 1)	(0.018)	-	(0.077)	
	[0.189]		[0.000]	

$$h_t = \left[cont, \left(i_{m,t-1} - i_{n,t-1}\right), \left(ts_{m,t-1} - ts_{n,t-1}\right), \left(ts_{m,t-2} - ts_{n,t-2}\right), \left(\hat{\sigma}^2\right) \right].$$

Significance levels:*=1%, **=5%, ***=10%. Newey-West standard errors in parentheses; p-values in brackets.

Time series GMM is used to correct the problem of serial correlation caused by the use of overlapping observations, wherein the horizon of interest rates surpasses the observed interval, and to provide asymptotically valid standard errors (Hansen and Hodrich 1980; White 1980; and Newey and West 1987.). Furthermore, GMM enables us to perform inference without the need to specify the distribution (Hall. 2005) and to examine directly the parameters derived from economic theory which fits in the time-series properties of the data (see table 1 above). Results from the GMM are reported in Table 5 where Section A summarizes the statistical results based on the assumption of a constant risk premium and the uses of instruments:

Results from models with instruments of

Table 5 Results from the Generalized Method of Moments for Malaysian Interest Rate Equations 6 & 10

(A)	α_n	β_n	δ_n	Hansen's test $x^2(1)$	Wald test $x^2(1)$
	-0.098**	0.091**		0.545	4876*
	(0.044)	(0.041)			
	{0.028}	{0.027}			
(B)					
	-0.114**	0.041**	-0.018	0.187	2563*
	(0.054)	(0.020)	(0.016)		
	{0.038}	{0.036}	{0.280}		

Notes: Newey–West standard errors in parentheses, p-values in brackets.*Denotes statistical significance at 1% level. ** Significance at the 5% level. *** Significance at the 10% level.

$$h_t = \left[cont, \left(i_{m,_{t-3}} - i_{n,_{t-3}}\right), \left(ts_{m,_{t-2}} - ts_{n,_{t-2}}\right), \left(ts_{m,_{t-1}} - ts_{n,_{t-1}}\right), \left(ts_{m,_{t-3}} - ts_{n,_{t-3}}\right) \right].$$

And time-varying risk premium are shown in Section B. Hansen's instrument validity test accepted the null hypothesis of independence of the instruments in the case of constant risk premium and time-varying risk premium. Hence, the choice of valid instruments is supported. Table 5 also shows whether the parameters are consistent with the theoretical value ($\beta = 1$)using the Wald test that is discussed in Newey and West (1987).

Our data in section (A) offer some evidence in support of the term structure of nominal interest rates containing some useful information for predicting changes in interest rates. This conclusion is based on the fact that our data reject the null hypothesis of $\beta = 0$ at 5% level of significance. More importantly, they are significantly different from the theoretical value of unity ($\beta = 1$) using Wald test. Following the Asian financial crises in 1997 when the Malaysian currency was subject to a massive speculative attack, it is therefore important to measure the risk premium to examine whether the risk premium has impact on the performance of the term structure. Since GARCH (1, 1) models tend to capture the volatility of many financial time series, we estimate GARCH (0, 1), GARCH (1, 0), and GARCH (1, 1). The result in Table 4 indicates that a GARCH (1, 1) model fit the data well, and therefore we use the implied series of the estimated values of $\hat{\sigma}_t^2$ as an approximate measure of the risk premium. This is similar to the strategy suggested by Pagan Ullah (1988). By incorporating risk premium into the analysis the results in section (B) add no value to the performance of the term structure of interest rate predictability of changes in short-term interest rate and still the slope parameter range between zero and unity. This implies the stability of interest rate in Malaysian fixed income securities.

CONCLUDING REMARKS

In this paper, we have examined the information content in the longer maturity term structure about future short-term interest rate in Malaysian fixed income securities market using data during 1992:02–2004:09. Regardless of a time-varying risk premium in the short-term interest rate, the GMM results suggest that the term structure in Malaysia provide some evidence to support the long-term implications of expectation theory. Furthermore, the Malaysian data offer some evidence that the covariance of the risk premium and the expected change in the short-term interest rate is not too large to significantly impact on the magnitude of the slope parameter. Thus, the longer maturity term structure is unbiased predictors and offers some evidence in support of the term structure of nominal interest rates containing some useful information for predicting changes in interest rates. This information extracted from term spread is important since it helps the monetary authorities to design appropriate interest rates policies in respond to the global market integration and financial sector deregulation and liberalization.

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